Pacific Island Network
Inventory & Monitoring Program

National Park Service
U.S. Department of the Interior

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Seafloor in 3D

Corals cover less than 0.1% of the ocean floor, yet contain levels of biodiversity that rival the rainforest. Coral reefs support multi-million dollar fishing and tourist industries in Hawaii, provide coastline protection from storms and typhoons, shelter countless organisms, and are the life-line for many families that rely directly on the ocean for sustenance. Worldwide, coral reefs are facing an ever-increasing number of natural and human-induced threats including: pollution, increasing sea-surface temperatures, over-fishing and destructive fishing practices, increasing disease occurrence, and ocean acidification.

Despite their crucial role, coral reef research and education are still in their infancy. Astonishingly, there are no reliable and cost effective methods of determining coral growth, a basic and essential parameter for understanding the health of a coral reef ecosystem. Furthermore, corals exist in three-dimensional (3D) space, and current methods of measuring coral growth rely on two-dimensional (2D) measurements.

Most corals are inaccessible to anyone who does not SCUBA dive, especially children. Until now, the only way to visualize corals has been to view static pictures or non-interactive films. As a result, public interest in the complexities of coral reefs pales in comparison to other charismatic megafauna such as sharks, whales and dolphins. We must continue to find ways to stimulate coral reef education.

Kalaupapa Project

During the week of May 19-23, 2014 a diverse team of scientists conducted a preliminary experiment examining the use of the latest 3D modeling software by *Autodesk, Inc.*, to model corals for scientific and educational purposes. This revolutionary software, *Reality Capture*, utilizes photogrammetry (making measurements using photographs), and is the first of its kind. For five days, a team of 8 divers captured Kalaupapa National Historical Park's coral reefs, gathering more than 2 terabytes of data (over 25,000 photographs). We photo-captured more than 30 corals, as well as 4 dead corals that will serve as the "controls". These "controls" will be laser scanned above water to serve as the reference model to which we will compare our 3D models (by comparing our models with the laser-scanned version, we can determine the accuracy of our methodology).

The Team

National Park Service
Sylvester Lee, Marine Biological Technician (KALA)
Eric Brown, Marine Ecologist (KALA)
Randall Watanuki, Maintenance Mechanic (KALA)
Scott Pawlowski, Chief of Cultural and Natural Resources (VALR)

Collaborating Organizations
The Hydrous
www.thehydro.us

Autodesk, Inc.
www.autodesk.com

Outcomes

Education: In the past, the only way to view a coral reef was through static, 2D photos, film, or in person. This new technology makes coral reefs accessible to people around the world. Educators are well aware that interaction is the key to an enriching learning experience. These interactive models will bring a new dimension to coral reef education and outreach. Ultimately, this technology will enhance the stimulation of an emotional interest to preserve, monitor, and conserve these precious resources.

Science: If this project proves to be successful, a new ability for Inventory & Monitoring Program scientists to accurately measure the surface area of corals over time will be a powerful tool to aid in long-term benthic monitoring efforts.

–S. Lee, NPS
Marine Biological Technician

Example of 2D Images Becoming a 3D Model

Step 1. Multiple pictures are taken around a coral head. The more complex the coral, the more pictures required. Proficient experience in SCUBA diving, underwater photography, and the software are required. Previous 3D modeling methods would require much more equipment including LIDAR (Laser Depth and Range), which is incredibly costly; this method only requires a camera.

Step 2. Individual Images are edited to optimize processing by the modeling software. Elements such as temperature, contrast, exposure, and saturation are adjusted.

Step 3. Images are imported into the software. Grey rectangles in this figure show where each image was taken in 3D space relative to the subject being modeled. The software automatically calculates the vantage point of each photo. It takes 1-2 hours to generate a model, which is superior to previous 3D model rendering methods, which required days to weeks.

Step 4. The software creates a mesh composed of hundreds of thousands to millions of mesh triangles. Previous 3D modeling software could only produce models with resolutions of a few thousand mesh triangles.

Step 5. Models are further post-processed through 3D editing software. The final product is an ultra-high resolution, true-color interactive 3D model. In previous methods, the entire process from photographing features to producing a 3D model took days to months. In this new method, the entire process can be completed in a few hours. You can visit this interactive model at http://thehydro.us/coral-in-3d/

Coral Bleaching Monitoring on Guam

In response to stresses such as higher water temperatures, corals can lose the symbiotic microscopic algae (which provides up to 95% of the coral's nutrition) from their tissues causing them to look white or "bleached". If favorable conditions return, corals can sometimes recover. However, bleached corals are more vulnerable to disease and other stressors, which can lead to death. This worldwide trend of coral bleaching is linked to global warming.

Coral reefs contain some of the most diverse ecosystems in the world and serve as critical habitats for thousands of species of marine organisms. Reefs support fisheries, protect coastlines from storms, and provide recreation. Coral bleaching resulting from higher sea surface temperatures threatens these resources. In 2013, an unprecedented coral bleaching event across Guam and the Marianas Archipelago was correlated with increased sea surface temperatures and reduced wind speeds for a four-month period. As a result, an astounding 85% of coral taxa showed signs of bleaching. This major event prompted the Guam Long-term Coral Reef Monitoring Program, NOAA, Guam EPA, the National Park Service, University of Guam, and Guam DAWR to work together to investigate the issue in an effort to promote coral reef resilience and recovery after such events.

Monitoring the coral reefs is a major activity of the National Park Service Inventory and Monitoring Program. National parks are partnering with research organizations like the University of Guam to study the impacts of bleaching on Guam's coral reefs.

Scientists from many stakeholder organizations began formal quantitative assessments of 3,600 photos from 48 reef sites on Guam.

University of Guam students photo surveying corals for signs of bleaching in War in the Pacific NHP

D. Burdick

They collect data on:

- The locations and depths of bleached corals
- The most vulnerable coral species
- The severity of the bleaching
- The size class of the corals which were bleaching
- Recovery of bleached colonies

These data will help us:

- To understand which corals may be resistant to coral bleaching
- To add to the understanding of which corals may be affected in future bleaching events
- To help resource managers both within and outside of park waters prepare for future bleaching events anticipated as a result of climate change

Preliminary results suggest:

- Recruitment of new corals is decreased during bleaching events
- Deeper coral colonies, even greater than 10 meters depth, can bleach when exposed to elevated sea surface temperatures
- Certain coral species are more susceptible to bleaching from extended elevated temperatures
- Different colonies of the same coral species can show different resistance to and recovery from bleaching

The Three R's

It started off like a normal day. We put on our long sleeves, repellent, and sunscreen, then set out into the forest above Asan Village at War in the Pacific NHP. We set up our transect tapes outlining the plot the day before to get a head start on our vegetation monitoring.

We were about an hour into our data collection when Meagan exclaimed, "Guys! I think I just found a UXO (unexploded ordinance)!" We all dropped what we were doing to check it out. Sure enough, there it was – a hand grenade just off of the transect. It looked old and rusty, blending in with the surrounding leaf litter.

We immediately left the area and called NPS Resource Management Chief, Mike Gawel. He assured us we were doing the right thing by following the three R's: Recognize, Retreat, Report. He told us to hold tight while he reported the UXO to 911. Minutes later, we received phone calls from the Guam Fire Department, and the Navy Explosive Ordinance Disposal Unit (EOD).We met both groups at the trail head. The EOD had us clear the area while they examined and collected data on the UXO. After calling the coast clear, we learned that it was a US "pineapple grenade" from WWII. They were able to safely collect the grenade and remove it from the area to be properly disposed of later that day in a controlled explosion at their base.

The day would have progressed differently had we not followed the safety guidelines created for these situations. Watch where you step out there. –M. Simon, NPS

Relics of War

The safety of our men and women in the field is paramount. Dangers take many forms and we must be prepared for them. When NPS Biological technicians Melissa Simon Lindsay Moore, and Elizabeth Urbanski, and UH Cooperator Meagan Selvig came across a WWII era grenade in a vegetation monitoring plot. They knew what to do.

Would you?

The I&M vegetation crew (the women) joined by the local fire department and the Navy's Explosive Ordnance Disposal Unit in War in the Pacific National Historical Park.

Algae Grazers Help Clean Up

Our Messes

The NPS Inventory & Monitoring Program began monitoring benthic (seafloor) and fish communities at Kalaupapa NHP (KALA) and Kaloko-Honokōhau NHP (KAHO) in 2006 and 2007, respectively. Results from these efforts have indicated that KALA has a more substantial fish assemblage in terms of biomass (total fish weight) compared to what has been observed at KAHO (Figure 1). At the same time coral cover at KAHO is substantially higher with less algal cover than what is seen at KALA (Figure 2).

The unique marine assemblages at these coastal parks provide an excellent opportunity to study nutrient inputs into nearshore waters, and its influence on benthic communities and the associated fish assemblage. Damaging algal blooms, a growing problem for Hawaii's coral reefs, have been linked to man-made nutrient inputs from land. As coastal land-use and nutrient inputs increase over time, grazing by fish, urchins, and turtles may naturally control algal growth and stem reef decline. These results and potential controlling factors have stimulated research questions such as:

What factors help explain why KALA has higher algal cover AND higher fish biomass, particularly herbivore biomass, which should theoretically keep the algae in check?

Would the larger human population adjacent to KAHO result in higher nutrients within park waters?

...and Support Marine Science in the Parks

To begin addressing these research questions, the University of Hawai'i at Hilo (UH) teamed with the NPS to investigate the response of algae to nutrient inputs, and the ability of grazers to control algal growth.

From 2011 to 2014, experiments were deployed at KAHO and KALA to investigate and compare: (1) nutrient inputs to the reef, (2) algal response (growth) to the inputs, (3) grazer communities, and (4) grazer control (consumption) of algal growth.

Preliminary results have documented significantly higher nitrate + nitrite concentrations at KAHO, and significantly higher ammonium concentrations at KALA. Phosphate concentrations were elevated for certain study stations at both parks. Nutrient source determination using stable isotope analysis is currently underway, helping scientists to understand specific sources of nutrient inputs to the reef.

In addition to differences in the fish assemblages between the two parks, UH researchers found that urchin densities were very low at KALA. However, reef substrates were dominated by intensively "cropped" algal turf assemblages, indicating that fish are actively consuming algae, and are the primary grazers at KALA. Alternatively, KAHO hosted very high densities of large, roving urchins that vigorously graze algae down to the underlying substrate, resulting in lower algal turf presence. The red pencil urchin (*Heterocentrotus mammillatus*), was found to be a primary grazer at KAHO. These differences in the overall grazer community structure are important factors in controlling algal growth at each park.

The preliminary results are encouraging and suggest that both nutrient inputs and grazing influence algal growth at both parks. Final results will help the NPS understand what actions are needed to effectively manage these resources.

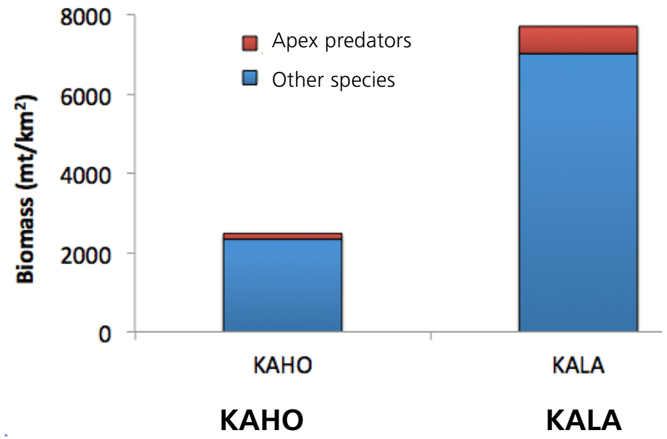
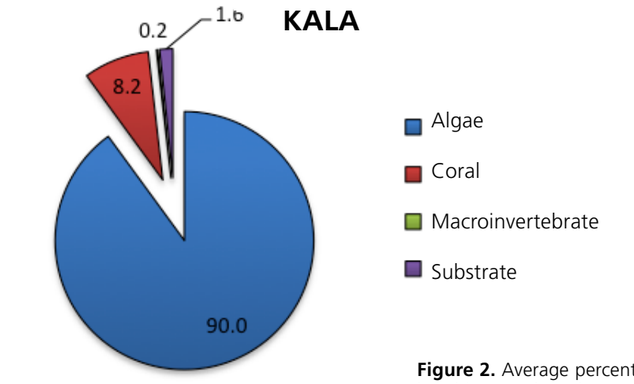


Figure 1. Average fish biomass (metric tonnes/kilometer²) at KAHO and KALA from 2007 to 2011.



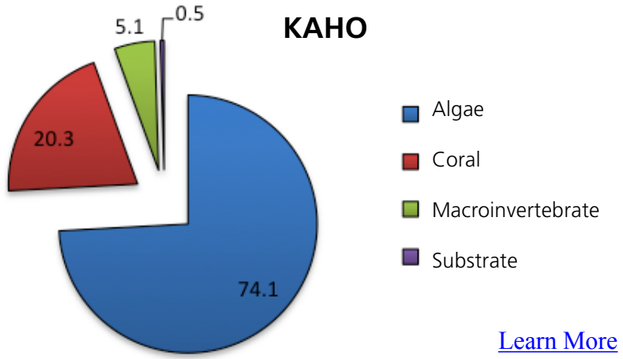


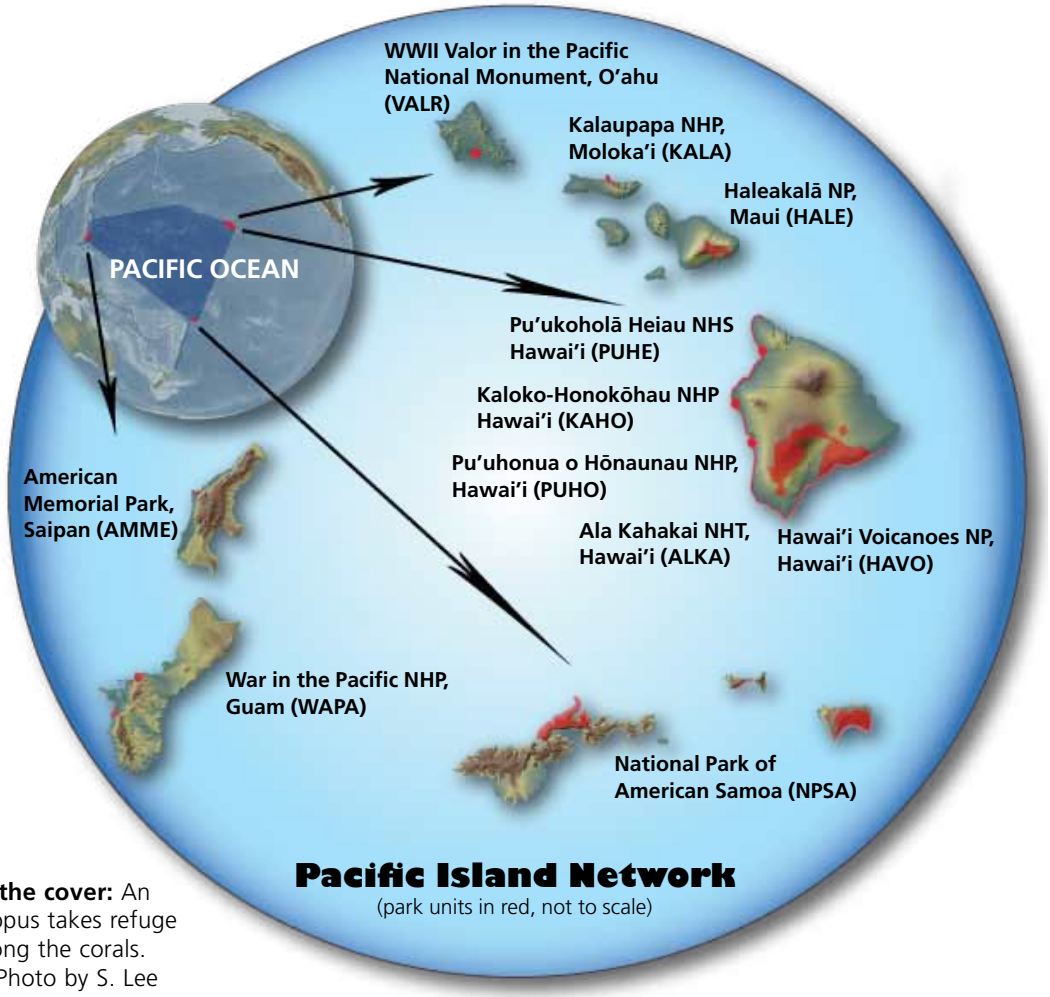
Figure 2. Average percent benthic cover by substrate type at KALA (2007 – 2011) and KAHO (only 2007 data).

Learn More

–E. Brown, NPS Marine Ecologist
–K.L. Kramer, UH-Hilo Marine Technician

Field Schedule

	July	August	September
Anchialine monitoring			
Invasive plants	HAVO (E.D. Pilot)	HALE (E.D. Pilot)	
Vegetation communities			
Water quality	WAPA (Marine) HALE	KALA	NPSA, WAPA, AMME
Stream animals		KALA	NPSA
Ground water			AMME
Benthic marine	WAPA		
Marine fish	WAPA		
Vegetation mapping	HALE	HALE	HALE
Climate (on-going)	All Parks----------	----------	----------



Pacific Island Network
(park units in red, not to scale)

On the cover: An octopus takes refuge among the corals.
-Photo by S. Lee

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The National Park Service (NPS) has implemented natural resource inventory and monitoring (I&M) on a servicewide basis to ensure all park units possess the resource information needed for effective, science-based management, decision-making, and resource protection.

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NOTE: Unless indicated all photos and articles are NPS.

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